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(54) Improvements in gear mechanisms

(57) A drive mechanism for a rack-and-pinion hoist consists of a motor 15 driving two pinions 18 and 19 which in turn mesh with the rack 14 of the hoist. The pinions 18 and 19 are driver by a common pinion 30 on the output shaft 31 of the gearbox 16 which is free to move in the direction A. This freedom of movement enables the drive mechanism to adjust itself automatically so that the drive is transmitted equally to the two pinions 18 and 19.

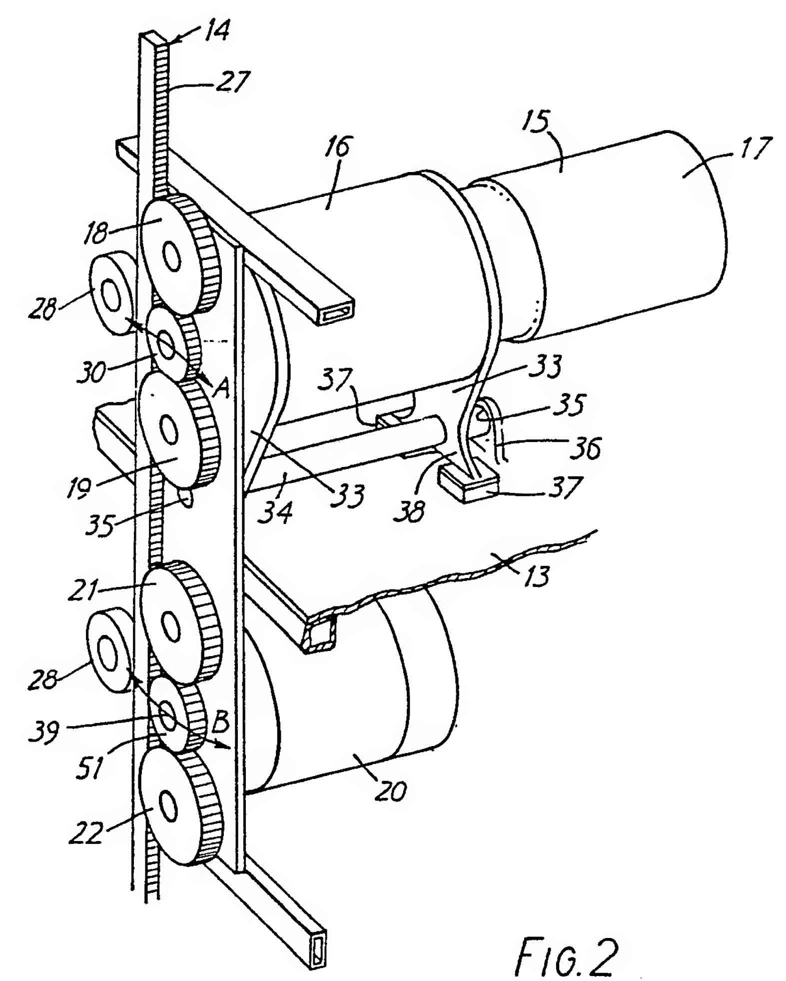

FIG. 2

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

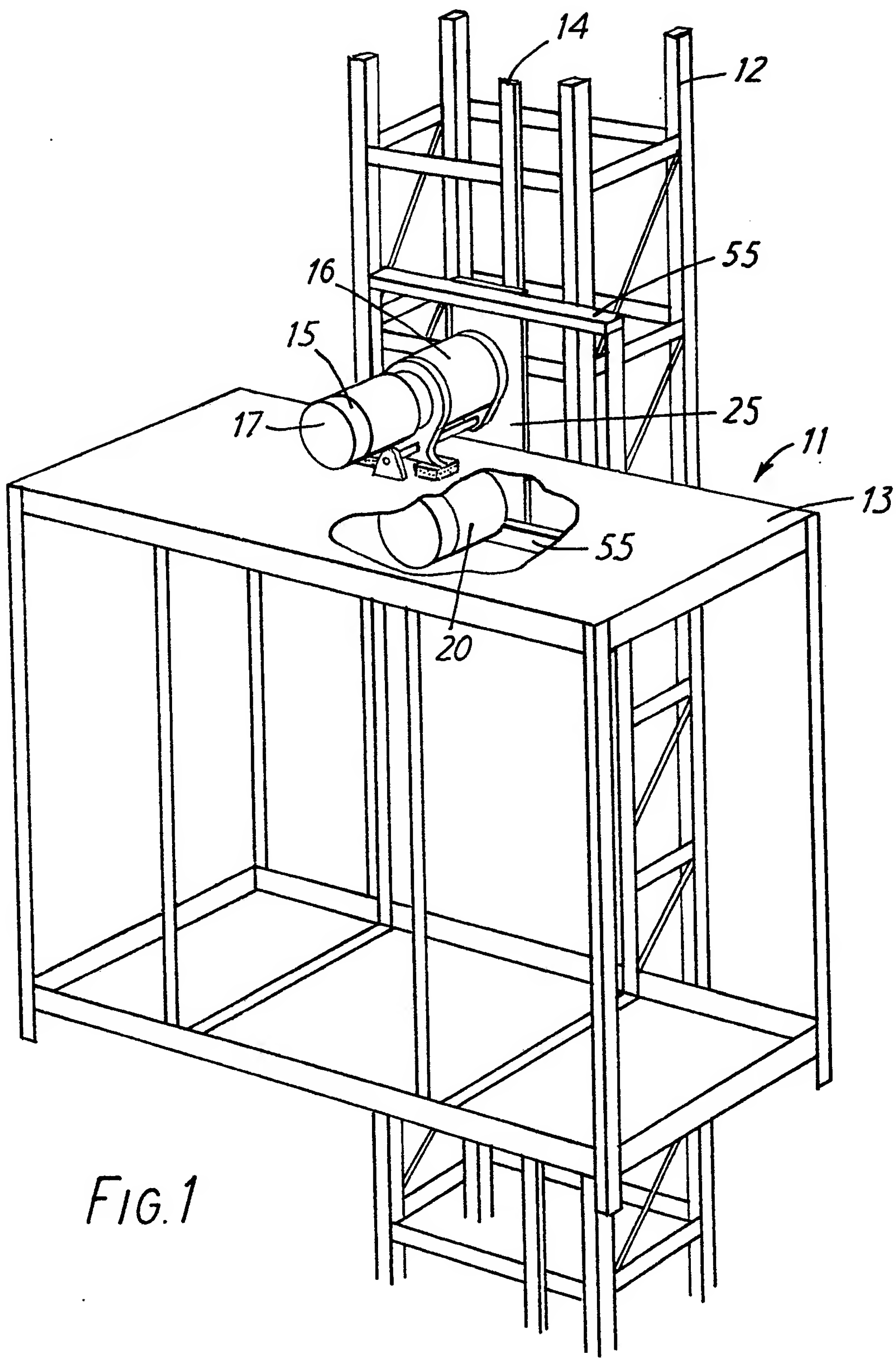

FIG.1

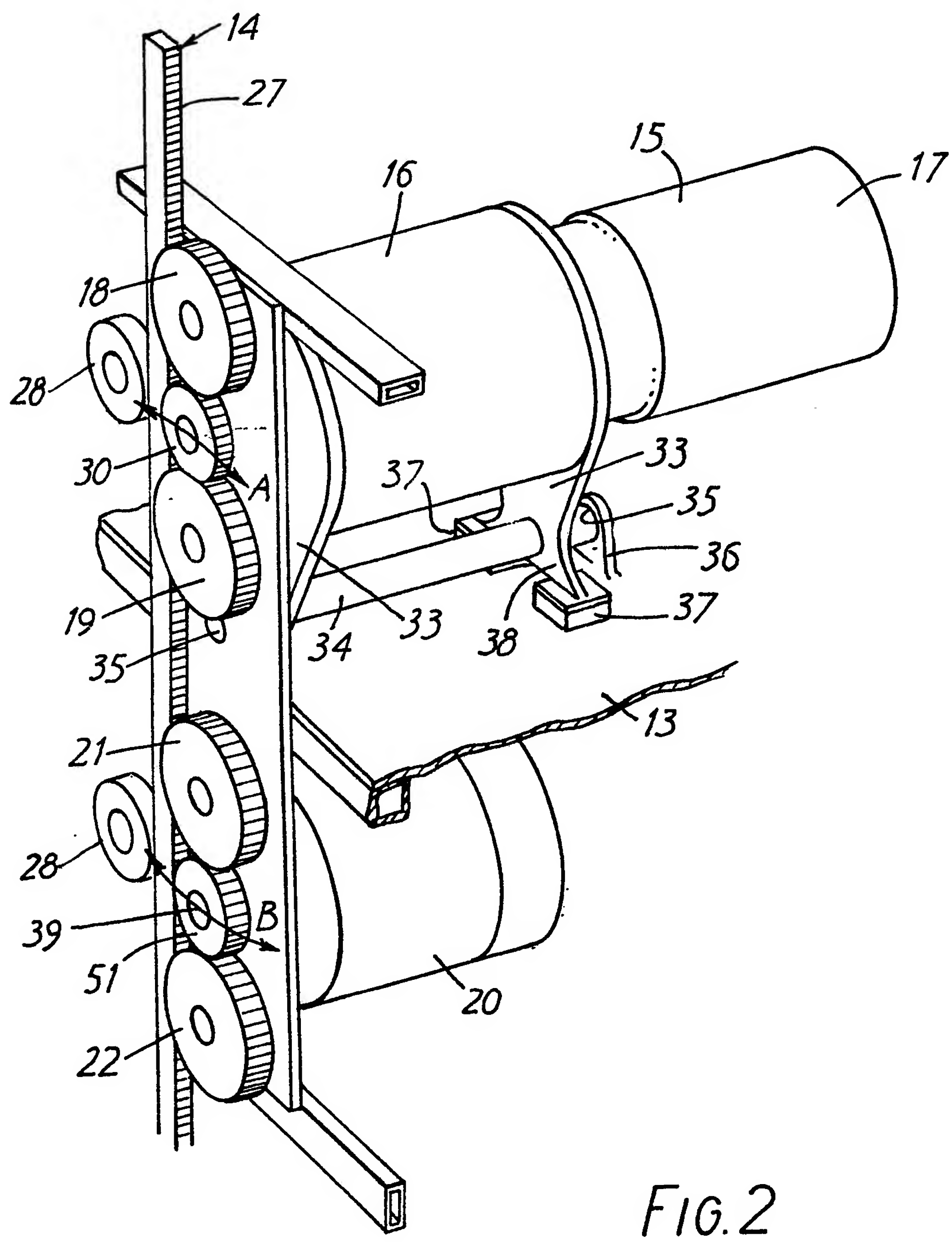
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FIG. 2

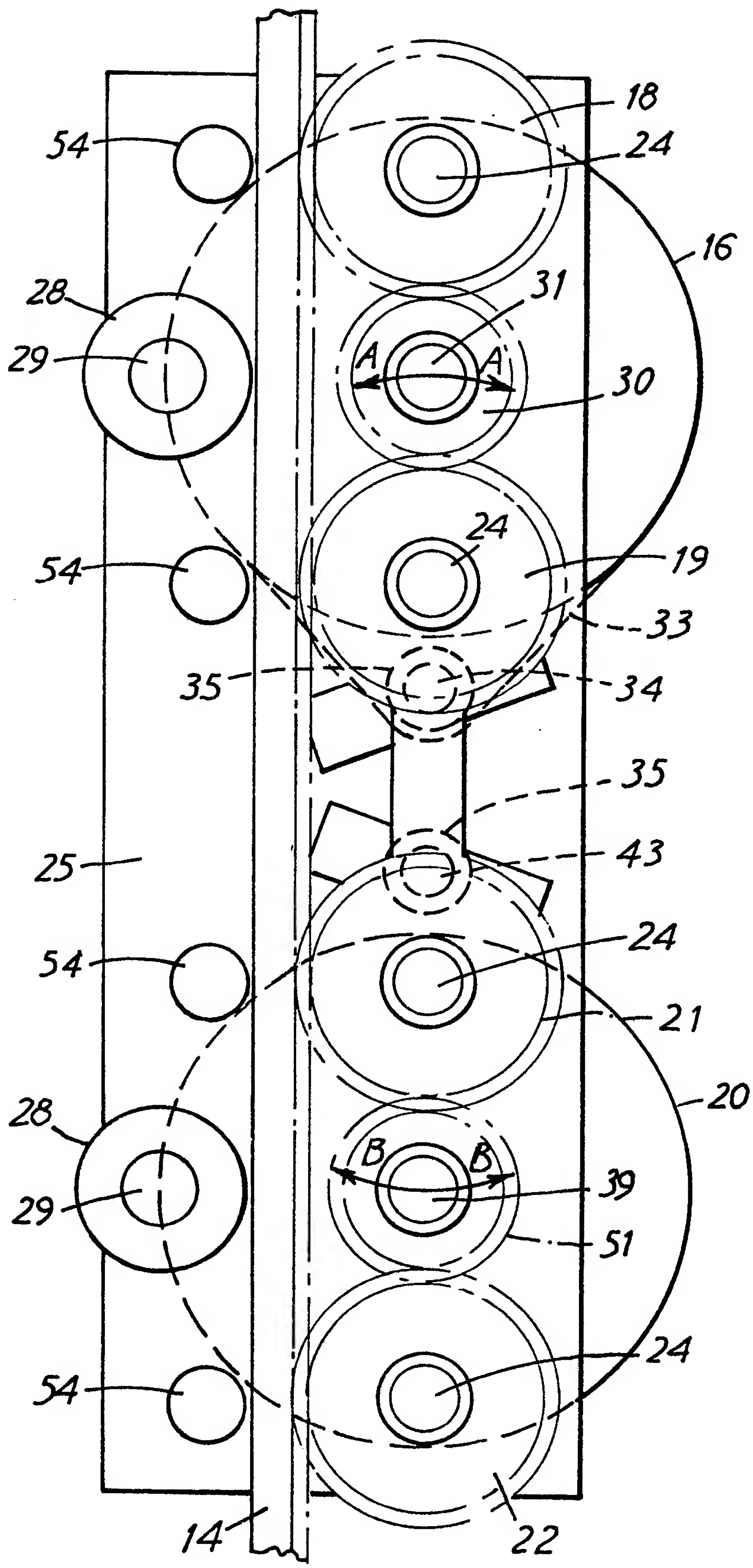

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FIG.3

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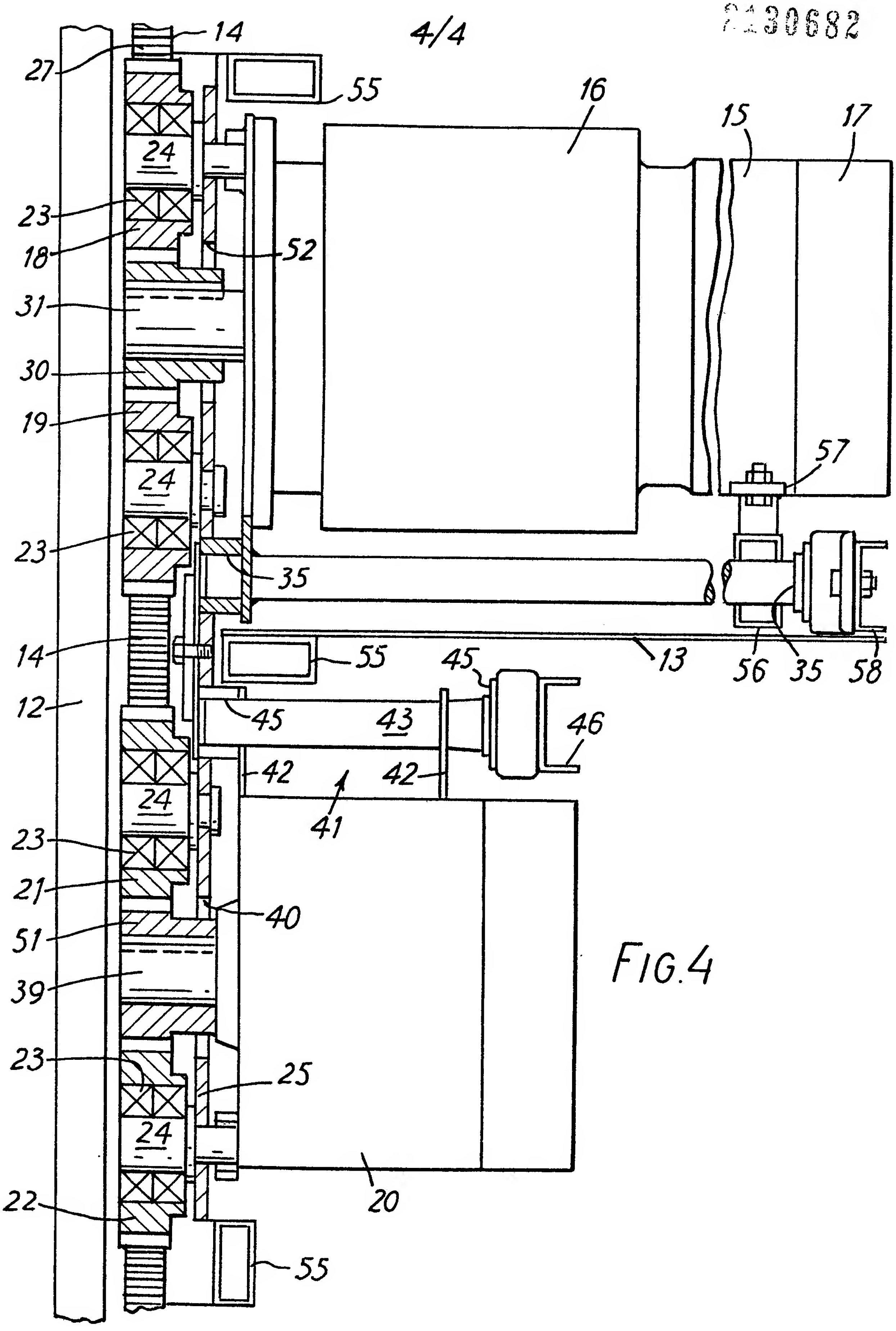

FIG.4

SPECIFICATION

Improvements in gear mechanisms

The present invention relates to improvements in gear mechanisms and is especially concerned with a gear mechanism for use in rack-and-pinion hoists.

A typical rack-and-pinion hoist, such as is used in the building and construction industry, consists of a tower which is erected in sections and a cage which moves up and down the tower. A vertical rack is fixed to the tower and the cage is driven by means of a motor or motors on the cage which has a driven pinion or pinions which engages the rack.

As a safety precaution rack and pinion hoists are usually fitted with an overspeed safety brake which is applied automatically if the hoist descends at a speed exceeding a certain value. Such safety brakes are usually tripped by a centrifugal mechanism driven by a pinion which meshes with the rack. The rotary part of the brake is also coupled to the pinion so that the braking forces are applied through the pinion to the teeth of the rack. Such an overspeed safety brake is described in our patent specification GB 2074673.

A hoist which has to carry a payload of up to 1 tonne can be driven satisfactorily by a single motor with a single pinion engaging a rack measuring 40 mm × 60 mm in cross section. For hoists with a larger load-carrying capacity this arrangement is not satisfactory because the load on the teeth of the rack is excessive. If a single pinion is to be used it is necessary to increase the cross-section of the rack so as to provide teeth of sufficient strength.

A machined steel rack is an expensive component of a rack and pinion hoist. The tower may be as high as 100 metres or even higher and the rack has to extend up the entire height of the tower. The cost of the rack is directly related to its cross sectional dimensions and tooth size. Increasing the size of the rack not only means increased cost of material but also increased costs in machining the teeth. Increasing the cross-section of the rack to enable the hoist to carry heavier loads therefore increases substantially the cost of the hoist.

To avoid having to increase the cross-section of the rack for hoists which carry payloads in excess of 1 tonne it has become normal practice to provide two motors, each fitted with its own pinion which meshes with the hoist rack. To employ more than two motors is cumbersome and creates expensive mounting problems. Even with two motor units there are problems of mounting and alignment.

Sites adjacent to the rack have to be provided not only for the two drive motors but also for the safety brake. This usually means that both motors and safety gear have to be mounted within the cage which intrudes on the usable space, or mounted outboard of the cage on the mast side which necessitates additional structural support framework. The preferred position is on the cage roof, but due to height limitations only one motor can be sited here.

It would be preferable to drive the two pinions by a common motor. This would avoid the problems of accommodating and aligning the second motor and would reduce costs. However in practice with known arrangements involving one motor driving two pinions, one pinion inevitably carries most of the load because of the difficulty of manufacturing the drive mechanism to sufficiently close tolerances to ensure that both pinions engage respective teeth of the rack simultaneously throughout the entire length of the rack.

The present invention is concerned to provide a gear mechanism which can be used in a rack and pinion hoist where a single motor drives two pinions and ensures that the load is shared between the two pinions.

According to the present invention there is provided a gear mechanism including a first gear wheel which is located between and meshes with second and third gear wheels, the three gear wheels rotating about parallel axes and the first gear wheel being mounted for limited translational movement relative to the second and third gear wheels in a direction substantially perpendicular to the plane defined by the axes of the second and third gear wheels.

In use, the first gear wheel will automatically adjust its position in the said direction so that the torque transmitted between the first and second gear wheels and the torque transmitted between the first and third gear wheels are substantially equal. When fitted as a drive mechanism for a rack and pinion hoist with the second and third gear wheels constituting pinions which mesh with the rack and the first gear wheels coupled to a common drive motor, the equalising of the torques means that the load of the cage and its contents is shared equally by the two pinions. In this way the load is shared by the teeth on the rack which engage the two pinions and the effects of variations in spacing of teeth arising from manufacturing tolerance, misalignment of rack sections and variations in wear on the teeth are reduced.

A further advantage of this arrangement is that the weight of the cage and its contents are borne by idler pinions and not by a gear wheel that is fixed to the output shaft of the motor gear unit. It is desirable to be able to use standard commercial motor gear units as the prime movers for the hoist. Indeed it may be uneconomic to have motors and gearboxes specially made for the purpose. However in commercially available power units the pinion is normally mounted directly on the output shaft of the gearbox of the motor gear unit. If this pinion meshes directly with the rack it is subject to very high radial loads, because the entire weight of the cage and its load is borne by the pinion or pinions. This heavy radial load has frequently meant that gearboxes employed in the past have been larger than is needed by the torque

transmitting requirements of the system. The additional weight of the larger gearbox detracts from the carrying capacity of the hoist. The larger gearbox is also likely to be more expensive. By using the gear mechanism of the present invention heavy radial loads on the output shaft of the motor can be avoided and thus the gear box need be no larger than is needed to meet the torque transmitting requirements.

The gear mechanism of the invention can also be used to couple an overspeed safety brake to two pinions which mesh with the rack of the hoist. At present most hoists of over 1 tonne carrying capacity have a single pinion drive to the safety brake even though two pinions are usually employed in the hoist drive system. The load applied to the teeth by the pinion of the safety brake when the brake is applied is likely to be greater than the total load applied by the two driving pinions because the teeth have to bear the forces of deceleration of the cage in addition to its weight. It is therefore as important for the safety brake to have two pinions in engagement with the rack as for the drive mechanism. It is, however, not practical to use two pinions, each driving a separate centrifugal brake, because one centrifugal mechanism may be triggered slightly before the other. The retarding effect of the first brake may mean that the hoist never reaches a speed sufficient to trigger the second brake.

By using the gear mechanism of the invention two pinions in engagement with the rack can be coupled to a single overspeed safety brake, the first gear wheel of the mechanism being coupled to the input shaft of the brake, the second and third gears constituting the pinions in engagement with the rack.

The use of the gear mechanism of the invention avoids heavy radial loads being applied to the input shaft of the brake.

For simplicity the second and third gear wheels may constitute the pinions in engagement with the rack as in the arrangements described above. However it is possible to construct a drive mechanism or a safety brake for a rack-and-pinion hoist in accordance with the invention in which the second and third gear wheels are intermediate gears in gear trains between the motor and the pinions engaging the rack. In this arrangement fourth and fifth gears coupled to the second and third gears would constitute the pinions of the rack-and-pinion drive.

The gear mechanism according to the invention may also be used in applications other than a rack and pinion hoist. For example, it may be used to drive two pinions which mesh with the teeth of a single larger gear wheel.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 shows a perspective view of a rack and pinion hoist in accordance with the present invention;

Fig. 2 shows a perspective view on an enlarged scale of the drive mechanism and overspeed safety brake of the rack and pinion hoist of Fig. 1;

Fig. 3 shows a side elevation partly in section of the drive mechanism and safety brake of Fig. 2 with slight modifications; and

Fig. 4 shows an end elevation of the drive mechanism and safety brake of Fig. 3.

Referring to Fig. 1 this shows a rack and pinion hoist 11 comprising a tower or mast 12 constructed in sections and a cage 13 mounted on the tower for movement up and down. A vertical rack 14 extends up the entire height of the tower. On top of the roof of the cage is a motor 15 with a gearbox 16 and an electro mechanical brake 17. The motor drives two identical pinions 18 and 19 (see Fig. 2) which mesh with the teeth of the rack to drive the cage up or down the tower 12. Beneath the roof of the cage is a safety brake 20 which is coupled to two pinions 21 and 22 which mesh with the rack 14. The safety brake is of the type described in our British Patent Specification No. 2074673 in which a centrifugal device driven by the pinions 21 and 22 trips the brake when the hoist exceeds a certain speed. The tripping of the brake causes brake pads to be applied against the brake discs which are driven in rotation by the pinions 21 and 22.

The pinions 18 and 19 and 21 and 22 are each rotatable mounted by means of ball race bearings 23 on parallel stub shafts 24 which are fixed in a mounting plate 25. The pinions are held on the stub shafts by circlips 26. The plate 25 is mounted on the cross-pieces 55 fixed to the central frame portion of the cage 13 so that the pinions 18 and 19 are above the level of the roof and the pinions 21 and 22 are below it. The four pinions are held in engagement with the teeth 27 of the rack 14 by two back-up rollers 28 which engage the back of the rack. The rollers 28 are rotatable mounted on stub shafts 29 fixed on the mounting plate 25. The rollers 28 and the pinions 18, 19, 21 and 22 all have parallel axes of rotation. As a safety measure stops 54 are fixed to the plate 25 so that there is normally a small clearance between the stops and the rack 14. In the event of the rollers 28 collapsing the stops 54 ensure that the pinions 18, 19, 21 and 22 cannot move out of engagement with the rack teeth (see Fig. 4).

The drive pinions 18 and 19 are driven by a common pinion 30 of smaller size than the pinions 18 and 19, fixed to the output shaft 31 of the gearbox 16. The pinion 30 is inserted through an opening 52 in the plate 25 and lies between the pinions 18 and 19 with its axis parallel to the axes of the pinions 18 and 19.

A sub-assembly consisting of the brake 17, the motor 15, the gearbox 16 and the pinion 30 is mounted on a support which allows the sub-assembly to move in a direction substantially perpendicular to the plane defined by the rotation axes of the pinions 18 and 19.

In Fig. 2 the support 32 consists of brackets or flanges 33 fixed at opposite ends of the gearbox casing and welded to a shaft 34. The shaft 34 is supported at opposite ends in bearing bushes 35 carried by the plate 25 and by a bracket 36 fixed

to the frame of the cage. The bushes 35 allow the shaft to rotate and the assembly to swing about the axis of the shaft. The shaft axis is parallel to and lies substantially in the plane defined by the axes of the pinions 18 and 19 so that the support 32 serves to guide the movement of the pinion 30 along an arc in a direction A substantially perpendicular to the plane defined by the axes of the pinions 18 and 19.

In the arrangement of Fig. 3 the support 32′ is slightly modified. Instead of having the two flanges 33 on the gearbox casing to support the sub-assembly, the support 32′ comprises one flange 33 at the output shaft end of the gearbox casing and a cross bar 56 of rectangular section which is fixed to mounting feet 57 on the casing of the motor 15. The shaft 34 passes through holes in the flange 33 and the crossbar 56 and is fixed to them by welding. The bearing 35 at the end of the shaft 34 remote from the plate 25 is supported by a crosspiece 58 of the frame of the cage rather than on a bracket 36.

Other arrangements for supporting the motor sub-assembly so as to permit movement in the direction A are possible. For example if the flange 33 adjacent the plate 25 is strong enough the whole sub-assembly can be supported in a cantilever manner from the flange with no further means of support.

The amount of movement in the direction A is limited by stops to prevent it being moved out of mesh with the pinions 18 and 19. These may take the form shown in Fig. 2 of buffers carried by legs 38 on the support 32 which engage the roof of the cage when the assembly has been rotated a certain amount in each direction. Alternatively a peg may be provided on the mounting plate which engages an arcuate slot in the part of the bracket 33 adjacent the plate 25. Abutment of the peg with the ends of the arcuate slot will then serve to limit the movement of the common pinion 30 in the direction A. In the modification shown in Fig. 3 the stops may be provided by buffers on the underside of the cross bar 56 which engage the roof of the cage. In practice it may be found that the pinion 30 will always remain in mesh with the pinions 18 and 19 without the provision of stops to limit the movement of the pinion.

When the common pinion 30 is rotated by the motor it causes the pinions 18 and 19 to rotate in the same sense as one another. The pinions 18 and 19 meshing with the teeth of the rack 14 cause the cage to move up or down the tower according to the sense of rotation of the motor. The freedom of the motor pinion 30 to move in the direction A allows the pinion to adjust its position automatically so as to ensure that the torque of the pinion 30 is transmitted equally to the pinions 18 and 19 with the result that they pass the load of the cage equally to the rack regardless of variations in the spacing of the teeth.

The weight of the cage and its load are carried equally by the pinions 18 and 19. The pinion 30 on the output shaft is not subjected to the heavy radial loads as would be the case if the pinions which engage the rack were mounted directly on the output shaft of the motor.

The pinions 21 and 22 which operate the overspeed safety brake mechanism are coupled to the brake by a similar gear mechanism. A common pinion 51 mounted on the input shaft 39 of the brake passes with clearance through an opening 40 in the plate 25 and lies between the pinions 21 and 22. A sub-assembly consisting of the brake 20 and the pinion 51 is mounted on a support 41 for movement in a direction substantially perpendicular to the plane defined by the rotation axes of the pinions 21 and 22. The support may consist of brackets or flanges 42 and a shaft 43. The shaft 43 is mounted in bearing bushes 45 in the plate 25 and a crosspiece 46 fixed to the framework of the cage below the roof. The bushes 45 allow the shaft to rotate so that the sub-assembly can swing about the axis of the shaft. The shaft axis is parallel to and lies substantially in the same plane as the axes of the pinions 21 and 22 so that as the sub-assembly swings the pinion 51 moves in the direction B substantially at right angles to the plane of the pinion axes 21 and 22.

The safety brake 20 can be of the same construction as any of the brakes described in our British Patent Specification No. 2074673. When the brake is triggered the retarding torque is applied by the brake through the input shaft and the pinion 51 to the pinions 21 and 22. The freedom of the pinion 51 to move in the direction B ensures that torque is transmitted equally to the pinions 21 and 22 and the load of the decelerating cage is shared equally by the teeth of the rack which engages the pinion 21 and those that engage the pinion 22.

With this arrangement the safety brake is less likely to fail due to overloading of the rack teeth than with a single pinion-driven safety brake.

CLAIMS

1. A gear mechanism including a first gear wheel which is located between and meshes with second and third gear wheels, the three gear wheels rotating about parallel axes and the first gear wheel being mounted for limited translational movement relative to the second and third gear wheels in a direction substantially perpendicular to the plane defined by the axes of the second and third gear wheels.

2. A gear mechanism according to claim 1 in which the second and third gear wheels mesh with a common set of gear teeth.

3. A gear mechanism according to claim 2 in which the said common set of gear teeth comprise the rack of a rack-and-pinion mechanism the second and third gear wheels constituting pinions.

4. A gear mechanism according to claim 1 in which the second and third gear wheels are coupled respectively with the fourth and fifth gear wheels which mesh with a common set of gear teeth.

5. A gear mechanism according to claim 4 in which the said common set of gear teeth comprises the rack of a rack-and-pinion

mechanism, the fourth and fifth gear wheels constituting the pinions.

6. A gear mechanism according to any of claims 1 to 5 in which the first gear wheel is carried by a support mounted for pivotal movement about an axis parallel to the axes of the gear wheels and lying substantially in the plane defined by the axes of the second and third gear wheels, whereby the pivotal movement of the support produces the translational movement of the first gear wheel relative to the second and third gear wheels.

7. A gear mechanism according to claim 6 in which the support carries stop to limit the pivotal movement of the frame so that the first gear wheel cannot move out of mesh with the second and third gear wheels.

8. A gear mechanism according to any of the preceding claims in which the first gear wheel is coupled to a drive motor.

9. A gear mechanism according to any of the preceding claims in which the first gear wheel is coupled to a brake.

10. A rack and pinion hoist including gear mechanism according to any of claims 1 to 7 in which the first gear wheel is coupled to the drive motor for the hoist and the second and third gear wheels engage the rack of the hoist.

11. A rack and pinion hoist including a gear mechanism according to any of claims 1 to 7 in which the second and third gear wheels are driven by the rack of the hoist and the first gear wheel engages an overspeed safety brake.

12. A gear mechanism substantially as hereinbefore described with reference to the accompanying drawings.

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